$$K = \frac{1}{1 + 0.005 \times (DCO + DCO_2) \times \alpha - 0.01 \times DH_2}$$

DH_2 = H_2 percent concentration in exhaust, dry, calculated from the following equation:

$$DH_2 = \frac{0.5 \times \alpha \times DCO \times (DCO + DCO_2)}{DCO + (3 \times DCO_2)}$$

W_{CO} = Mass rate of CO in exhaust, [g/hr]
M_{CO} = Molecular weight of CO = 28.01
W_{NOx} = Mass rate of NO_X in exhaust, [g/hr]
M_{NO2} = Molecular weight of NO_2 = 46.01
K_H = Factor for correcting the effects of humidity on NO_2 formation for four-stroke gasoline engines; see the equation below:

$$K_H = \frac{1}{1 - 0.0329 \times (H - 10.71)}$$

Where:
H = specific humidity of the intake air in grams of moisture per kilogram of dry air. For two-stroke gasoline engines, KH should be set to 1.

(d) The final reported emission test results must be computed by using the following formula for each individual gas component:

$$Y_{wm} = \frac{\Sigma(W_i \times f_i)}{\Sigma(P_i \times f_i)}$$

Where:
Y_{wm} = Weighted mass emission level (HC, CO, NO_x) for a test [g/kW-hr].
W_i = Average mass flow rate (W_{HC}, W_{CO}, W_{NOx}) of an emission from the test engine during mode i, [g/hr].
f_i = Weighting factors for each mode according to § 91.410(a)
P_i = Average power measured during mode i, [kW], calculated according to the formula given in § 91.423(b). Power for the idle mode shall always be zero for this calculation.

(e) The final reported weighted brake-specific fuel consumption (WBSFC) shall be computed by use of the following formula:

$$WBSFC = \frac{\Sigma(F_i \times f_i)}{\Sigma(P_i \times f_i)}$$

Where:
WBSFC = Weighted brake-specific fuel consumption in grams of fuel per kilowatt-hour (g/kW-hr).
F_i = Fuel mass flow rate of the engine during mode i, [g/hr].
f_i = Weighting factors for each mode according to § 91.410(a)
P_i = Average power measured during mode i, [kW], calculated according to the formula given in § 91.423(b). Power for the idle mode shall always be zero for this calculation.

§ 91.420 CVS concept of exhaust gas sampling system.

(a) A dilute exhaust sampling system is designed to directly measure the true mass of emissions in engine exhaust without the necessity of measuring either fuel flow or intake air flow. This is accomplished by diluting the exhaust produced by an engine under test with ambient background air and measuring the total diluted exhaust flow rate and the concentration of emissions within the dilute flow. Total mass flow of an emission is then easily calculated.

(b) A constant volume sampler (CVS) is typically used to control the total amount of dilute flow through the system. As the name implies, a CVS restricts flow to a known value dependent only on the dilute exhaust temperature and pressure.

(c) For the testing described in this subpart, a CVS must consist of: A mixing tunnel into which the engine exhaust and dilutant (background) air are dumped; a dilute exhaust flow metering system; a dilute exhaust sample port; a background sample port; a dilute exhaust sampling system; and a background sampling system.

(1) *Mixing tunnel.* The mixing tunnel must be constructed such that complete mixing of the engine exhaust and background air is assured prior to the sampling probe.

(2) *Exhaust flow metering system.* A dilute exhaust flow metering system must be used to control the total flow rate of the dilute engine exhaust as described in § 91.421.

(3) *Exhaust sample port.* A dilute exhaust sample port must be located in or downstream of the mixing tunnel at a point where complete mixing of the

engine exhaust and background air is assured.

(4) *Background sample port.* A dilute background sample port must be located in the stream of background air before it is mixed with the engine exhaust. The background probe must draw a representative sample of the background air during each sampling mode.

(5) *Exhaust sampling system.* The dilute exhaust sampling system controls the flow of samples from the mixing tunnel to the analyzer system. This could be either a continuous sampling system or grab (bag) sampling system. If a critical flow venturi (CFV) is used on the dilute exhaust sample probe, this system must assure that the sample CFV is in choke flow during testing. If no CFV is used, this system must assure a constant volumetric flow rate through the dilute exhaust sample probe or must incorporate electronic flow compensation.

(6) *Background sampling system.* The background sampling system controls the flow of samples from the background air supply to the analyzer system. This could be either a continuous sampling system or grab (bag) sampling system. This system must assure a constant volumetric flow rate through the background sample probe.

§ 91.421 Dilute gaseous exhaust sampling and analytical system description.

(a) General. The exhaust gas sampling system described in this section is designed to measure the true mass emissions of engine exhaust. This system utilizes the Constant volume Sampling (CVS) concept (described in § 91.420) of measuring mass emissions of HC, NO_x, CO, and CO_2. Grab sampling for individual modes is an acceptable method of dilute testing for all constituents, HC, NO_x, CO, and CO_2. Continuous dilute sampling is not required for any of the exhaust constituents, but is allowable for all. Heated sampling is not required for any of the constituents, but is allowable for HC and NO_x. The mass of gaseous emissions is determined from the sample concentration and total flow over the test period. As an option, the measurement of total fuel mass consumed over a cycle may be substituted for the exhaust measurement of CO_2. General requirements are as follows:

(1) This sampling system requires the use of a Positive Displacement Pump—Constant Volume Sampler (PDP–CVS) system with a heat exchanger, or a Critical Flow Venturi—Constant Volume Sampler (CFV–CVS) system with CVS sample probes and/or a heat exchanger or electronic flow compensation. Figure 2 in appendix B of this subpart is a schematic drawing of the PDP–CVS system. Figure 3 in appendix B of this subpart is a schematic drawing of the CFV–CVS system.

(2) The HC analytical system requires:

(i) Grab sampling (see § 91.420, and Figure 2 or Figure 3 in appendix B of this subpart) and analytical capabilities (see § 91.423, and Figure 4 in appendix B of this subpart), or

(ii) Continuously integrated measurement of diluted HC meeting the minimum requirements and technical specifications contained in paragraph (b)(2) of this section.

(iii) The dilute HC analytical system for marine spark-ignition engines does not require a heated flame ionization detector (HFID).

(iv) If used, the HFID sample must be taken directly from the diluted exhaust stream through a heated probe and integrated continuously over the test cycle.

(v) The heated probe must be located in the sampling system far enough downstream of the mixing area to ensure a uniform sample distribution across the CVS duct at the sampling zone.

(3) The CO and CO_2 analytical system requires:

(i) Grab sampling (see § 91.420, and Figure 2 or Figure 3 in appendix B of this subpart) and analytical capabilities (see § 91.423, and Figure 4 in appendix B of this subpart), or

(ii) Continuously integrated measurement of diluted CO and CO_2 meeting the minimum requirements and technical specifications contained in paragraph (b)(4) of this section.

(4) The NO_X analytical system requires:

(i) Grab sampling (see § 91.420, and Figure 2 or Figure 3 in appendix B of